What is claimed is:

1. The method for simulating dental procedures for training dental students comprising, in combination, the steps of:

employing a digital computer consisting of a processor and a display device to display a model of a tooth,

employing said digital computer and display device to display a model of a dental tool, and

employing a haptic interface device that is manually moveable by a dental student and coupled to said digital computer to move the said model of a dental tool with respect to said model of a tooth to haptically simulate a dental procedure.

2. The method set forth in claim 1 wherein said dental tool is a pick having a handle and wherein said haptic interface includes a stylus movable by said dental student to simulate the motion of said handle.

3. The method set forth in claim 1 wherein said dental tool is a drill having a handle and wherein said haptic interface includes a stylus movable by said dental student to simulate the motion of said handle.

4. The method set forth in claim 1 wherein said dental tool is an amalgam carrier having a handle and wherein said haptic interface includes a stylus movable by said dental student to simulate the motion of said handle.

5. The method set forth in claim 1 wherein said dental tool is a carver having a handle and wherein said haptic interface includes a stylus movable by said dental student to simulate the motion of said handle.

6. The method set forth in claim 1 wherein said model of a dental tool is selected by said student from a plurality of available dental tools, each of which has a handle, and wherein said haptic interface includes a stylus movable by said dental student to simulate the motion of the handle of each of said tools.

7. The method set forth in claim 6 wherein said plurality of dental tools comprises at least a pick, a carver, and a drill.

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8. The method set forth in claim 6 wherein said plurality of dental tools comprises at least a pick, a carver, a drill and an amalgam carrier.

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9. The method set forth in claim 1 wherein said display device renders said model of a tooth and said model of a dental tool in a stereoscopic three dimensional display.

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10. The method set forth in claim 1 wherein said a haptic interface device that is manually moveable by a dental student includes a moveable stylus that is moveable in at least three degrees of freedom.

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11. The method set forth in claim 1 wherein said display device renders said model of a tooth volumetrically as a solid object consisting of a collection of volume elements.

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12. The method set forth in claim 12 wherein said model of a tooth is subdivided into different regions simulating different materials said materials including enamel, dentin and pulp.

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13. The method as set forth in claim 1 wherein said model of a dental tool represents a drill, said method further including the step of removing portions of said model of a tooth that are intersected by said drill.

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14. The method as set forth in claim 1 wherein said model of a dental tool represents an amalgam carrier, said method further including the step of adding material to portions of said model of a tooth in the vicinity of said amalagam carrier.

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15. The method for simulating dental procedures as set forth in claim 11 wherein said digital computer further includes means for storing volumetric object grid data specifying the attributes of at least selected ones of said volume elements.

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16. The method for simulating dental procedures as set forth in claim 14 further including the step of responding the movement of said model of a dental tool with respect to said model of a tooth by modifying said volumetric object grid data.

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17. The method for simulating dental procedures as set forth in claim 15 further

2 including the step of responding the movement of said model of a dental tool with respect
3 to said model of a tooth by modifying said volumetric object grid data and said data
4 specifying the attributes of at least selected ones of said volume elements.

1   18.   The method for simulating dental procedures as set forth in claim 17 wherein
2 said digital computer further includes means for storing data for representing the shape
3 and character of a modification region of said model of a dental tool to control the
4 manner in which said volumetric object grid data is modified.

1   19.   Apparatus for simulating dental procedures for training a dental student
2 comprising, in combination, a digital computer consisting of at least a processor, a
3 display device, a haptic interface including a moveable stylus manipulatable by said
4 student, and storage means for storing:
5   volumetric object grid data for representing a tooth as a collection of volume elements
6 in three-dimensional space,
7   tool definition data for representing the shape and character of a modification region of
8 a dental tool in three-dimensional space, and
9   a simulation program executable by said processor in response to the movement of said
10 stylus for moving a displayed model of said dental tool with respect to a displayed model
11 of said tooth to haptically simulate a dental procedure.

1   20.   Apparatus as set forth in claim 19 wherein said storage means further stores
2 attribute grid data specifying the attributes of at least selected ones of said volume
3 elements.

1   21.   Apparatus as set forth in claim 20 wherein said storage means further stores
2 tool definition data specifying the characteristics of said dental tool.

1   22.   Apparatus as set forth in claim 21 wherein said tool definition data specifies
2 the shape and location of a modification region of said dental tool and wherein said
3 simulation program includes means for modifying said object grid data for volume
4 elements in the vicinity of said modification region.

1   23.   Apparatus as set forth in claim 22 wherein said simulation program further
2 includes means for modifying said attribute grid data describing volume elements in the
3 vicinity of said modification region.

24.   Apparatus as set forth in claim 23 wherein said tool definition data further includes the specification of the location of feel points relative to said modification region and wherein said simulation program includes means for controlling haptic forces applied to said stylus when said modification region of said dental tool is moved near to said tooth.

25.   Apparatus as set forth in claim 24 wherein at least some of said feel points define the location of a handle portion of said dental tool.

26.   Apparatus as set forth in claim 24 wherein at least some of said feel points are positioned outwardly from said modification region to increase the amount of force that the student must apply to said stylus to modify data representing said tooth

27.   Apparatus as set forth in claim 24 wherein at least some of said feel points are positioned inwardly into said modification region to decrease the amount of force that the student must apply to said stylus to modify data representing said tooth.

28.   Apparatus as set forth in claim 24 wherein as least some of said feel points are spaced from adjacent ones of said feel points by a distance larger than the dimension of projecting portions of said tooth thereby facilitating the removal of said projecting portions.

29.   Apparatus as set forth in claim 24 wherein at least some of said feel points are positioned relative to said modification region to guide the movement of said modification region with respect to said model of a tooth.

30.   Apparatus as set forth in claim 23 wherein said tool definition data further includes the specification of the location of one or more sensor points relative to said modification region for determining the attributes of volume elements of said tooth located at said sensor points.

31. Apparatus as set forth in claim 30 wherein said tool definition data includes the specification of the location of a single sensor point located substantially at the center of mass of said modification region.

1   32. Apparatus as set forth in claim 30 wherein said tool definition data further includes

2   the specification of the location of one or more sensor points at or near the location of

3   one or more selected ones of said feel points for determining the attributes of volume

4   elements of said tooth at said sensor points.